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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

D. W. MAY, Agronomist in Charge,

Mayaguez, P. R.

**Under the Supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.**

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of A. C. TRUE, Director, States Relations Service, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., October 18, 1920.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1920.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
Director, States Relations Service,
U. S. Department of Agriculture, Washington, D. C.

Publication recommended.
A. C. TRUE, *Director.*

Publication authorized.
E. T. MEREDITH,
Secretary of Agriculture.

¹ Resigned Aug. 10, 1920. ² Resigned Aug. 26, 1920. ³ Appointed Sept. 7, 1920.

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1920.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

INTRODUCTION.

During the fiscal year 1920 Porto Rico experienced the greatest prosperity it has ever known. The crops generally were good and the prices received for them were high. Not only was trade with foreign markets far greater than ever before, but living conditions were very much improved owing to the increased production of food for home consumption. External trade amounted to \$247,200,000, approximately \$150,000,000 of which represented material exported from Porto Rico. This was an increase of \$70,000,000 in exports over the previous year. Products imported were valued at \$96,000,000, which was a gain of \$34,000,000 over 1919. This shows a balance of trade largely in favor of the island.

SUGAR.

The sugar exported from Porto Rico in 1920 showed an increase of 68,000 tons over the amount shipped last year. The average price obtained per ton was almost \$100 greater than the price per ton in 1919. This represents an average of $11\frac{1}{4}$ cents a pound, or a gain of $4\frac{1}{2}$ cents a pound in 1920. It is not likely that such high prices will continue, and planters need to prepare to meet the situation that may be caused by a fall in sugar prices by making a thorough study of their business now. As a preliminary step the land should be put in systems of rotation. The lands in Porto Rico have been kept in cane too long. The old method of allowing them to grow up to pasture for two years or more is no longer followed because of the increased value of land and the great demand for sugar.

It is difficult to get Porto Ricans to plant cane in rotation with other cultivated crops. The station has made great efforts to induce them to grow rice in rotation with cane. This crop, however, requires special irrigation of the land and machinery for seeding, flooding, harvesting, and thrashing. While labor is abundant and

reasonably cheap, rice can not be grown here by oriental methods; and it does not seem possible at present to get planters to put in machinery needed for rice cultivation. During the past two years some attempts were made to grow rice, but the effort was only half-hearted and spasmodic, owing to the fact that the sugar crops brought greatly increased prices. A few crops of rice have been grown here and there, but the land has invariably gone back to cane. Legumes give great promise as a rotation crop with cane. The growing of beans in the young cane is a practice that will probably be continued by the laborers. The station has introduced some other legumes which are better adapted to land that is broken after cane and wholly devoted to the new crop. The velvet bean is one of the more promising sorts, as it not only improves the soil but provides excellent forage for the work animals. Another legume that is giving splendid results is sunn hemp (*Crotalaria juncea*). This crop has given enormous yields within a very short time.

Cane is usually planted in the winter time and harvested the following winter. There is a practice followed here, however, of planting the cane in the summer and carrying it over for 15 or 18 months before harvesting it. Where ratoon cane is cut for the last time in the winter, the land should be broken and planted to *Crotalaria*, which may be pastured and turned under in the summer. Cane should then be planted and allowed to grow for 18 months before it is cut. In this way a great deal of organic matter and nitrogen can be returned to the soil without any great interruption to the sugar-cane crop.

In general, it may be said that the yield of sugar could be greatly increased on the average farm in Porto Rico were more and better cultivation given the land. Owing to the fact that the cultivation of cane lands is at best an expensive affair, it would be well to do more plowing and less hoeing, and to stir the soil frequently. More than \$3,000,000 was paid during the fiscal year 1920 for imported fertilizer, most of which was applied to the cane crops. A great deal of this fertilizer was bought to very poor advantage, and in many instances it failed to fill the most urgent need of the field to which it was applied. Every planter is advised, therefore, to make a closer study of the requirements of the various types of soil. Fertilizers are always more or less uncertain, and it is well to learn what rôle they play in the production of a crop and what effect they have on the soil to which they are applied.

The future of sugar cane, the principal crop of Porto Rico, has generally been overshadowed by a cloud. First, it was the changa or West Indian mole cricket and the May beetle, then a fungus disease, and last, the mottling or mosaic disease. However, these difficulties have been considerably controlled by natural and artificial

measures. The mosaic disease of cane showed less virulence during the past year, although it is still a factor to be reckoned with. This disease has been combated largely by the introduction of immune or partially immune varieties. Some varieties, such as the Kavangire, a cane of the Japanese type (Pl. VI, fig. 2) appear to be wholly immune. Other varieties, including many seedlings produced on the island and some brought from Java, are partially immune, and, though showing some symptoms of the disease, make a good growth and produce large yields in spite of it. Roguing fields of the infested stools gives economic results where there is only little disease present.

The work of the station with sugar cane has been largely a matter of growing new varieties from the seed in the tassel. This method gives a greater return for the time and money expended than any line that can be followed consistently from year to year. The new varieties produced are legion. By continually eliminating the unfit and least productive plants, the station hopes to develop varieties that will be less susceptible to disease than the cane now grown in Porto Rico. It also aims to secure varieties giving greater tonnage and larger sugar content than is now obtained.

LIVE STOCK.

One of the most promising lines of agriculture is the production of live stock, yet this industry is very poorly developed in Porto Rico. No system of agriculture is complete or well grounded unless it includes within its scope the production of animals. Even in cases where a country produces a specialty for a certain market, as, for example, the Channel Islands, which grow potatoes and tomatoes for trade with London, live stock is needed to consume the waste products of the farm and to conserve the fertility of the soil. The present practice of growing only one remunerative crop without certain necessary adjuncts, such as animal farming, is unsafe, too often unprofitable, and is not rounded out, perfected agriculture. At present there is not enough poultry produced in Porto Rico to supply local demands. Very few farmers produce enough hogs to meet their own needs. In fact, there are not enough pigs on the island to utilize kitchen waste. The pork and lard imported into Porto Rico during the year amounted to more than \$3,500,000. Such an enormous expense would be saved were the pig stock increased and improved. This could be brought about by growing throughout the year forage and other crops especially for hogs and by fencing in the hog pastures. The time has passed when growing pigs should be tied out with a rope or kept penned up. Fencing should be provided for them and crops kept growing so that the animals will not need imported concentrates. A rotation of pastures and even fruit

and coffee groves would provide an excellent means for increasing pig production, and at the same time it could be handled in such a manner as to improve the condition of the soil and conserve labor.

A considerable number of purebred cattle were imported into Porto Rico during the year. As cattle tick and tick fever are found throughout the island, great caution should be exercised about bringing in purebred cattle. In the first place it is impossible to turn such cattle into the fields and expect them to prosper as native cattle do. They must be kept stabled and as far as possible be kept free from ticks. Unless the farmer is prepared to do this he had better confine his purchases to a purebred bull to upgrade his herd. Porto Rico has an excellent race of native cattle. They have not been bred for any special purpose. Their conformation is good, but could be improved in a few generations by judicious crossings with improved breeds, the breeder following the lines he desires. The herd can be bred for milking qualities or for beef production or reproduced with a view to maintaining ability to work. Strong work animals will be needed on the plantations for years to come. A good many tractors are being sold on the island, yet the ox must do certain work, and does it at less cost than would the tractor, the horse, or the mule. The work oxen are capable of maintaining themselves on the poorest grasses and under rather harsh treatment and can not well be dispensed with.

Of late years the tendency in breeding cattle has been toward the dairy type. In improving the herds for milk yield it should be remembered that the male offspring must be employed as work animals. For this reason there should be selected a breed which will cross well with the native stock, improve the milk yield, and also produce strong work animals for the plantations. The station has developed a herd of Guernsey cattle (Pl. I, figs. 1 and 2). This breed is somewhat similar to the native stock in form and color, and the resulting crosses are not only showing greatly increased dairy capacity, but they are strong, stocky, and apparently well adapted to working. Moreover, the breed has short hair, which affords less protection for the cattle tick.

The great drawback to the cattle industry in Porto Rico is the cattle tick. This pest, in addition to carrying tick fever from animal to animal, greatly saps the strength of the individual by sucking its blood. Were it eliminated, the cattle industry should make wonderful progress in a short time, and no doubt a race of cattle could be developed here as famous as those of some other countries where special purpose animals are produced. About 50 dipping tanks, modeled after the first tank established by the station several years ago, are now located in various sections of the island. Others are

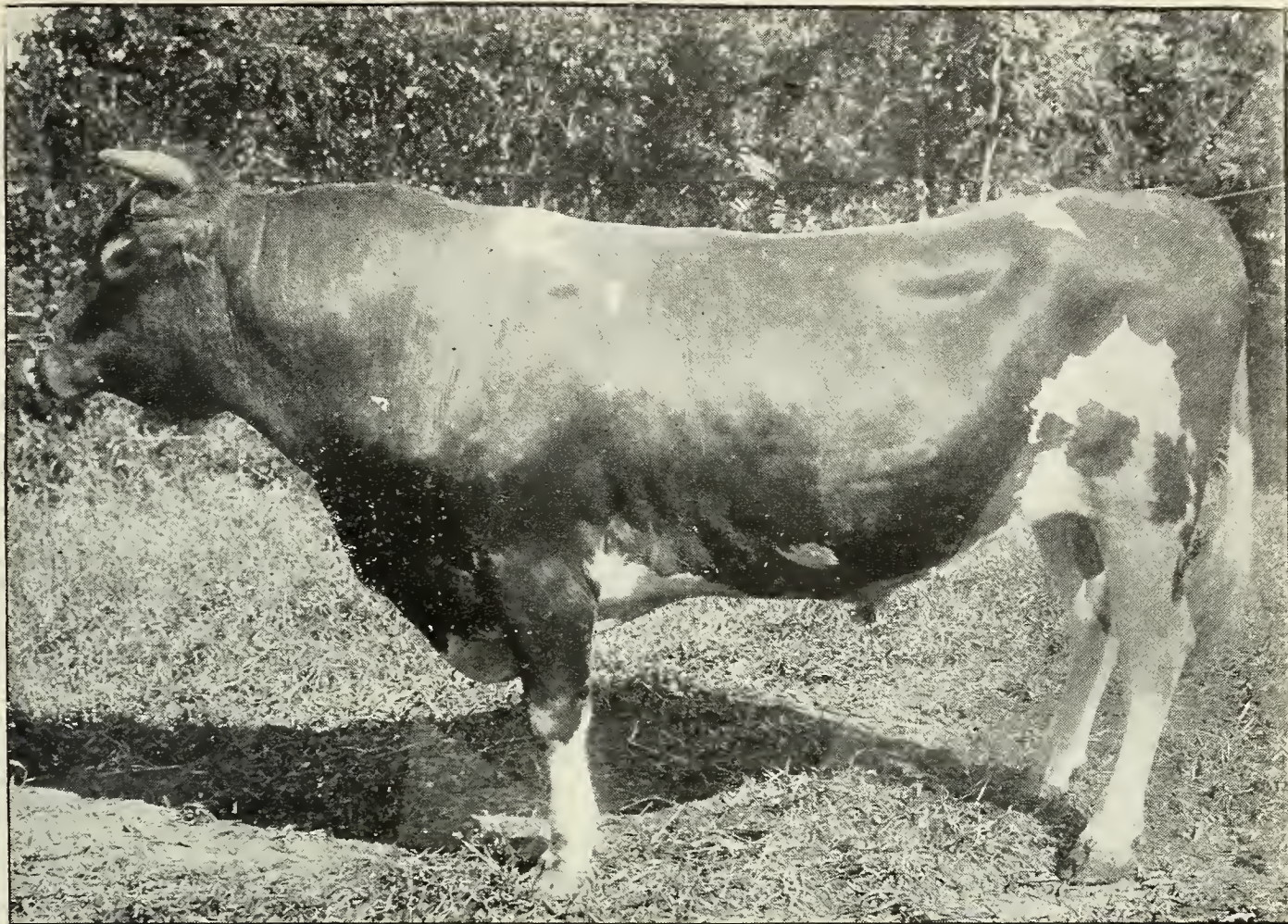


FIG. 1.—STATION GUERNSEY BULL.

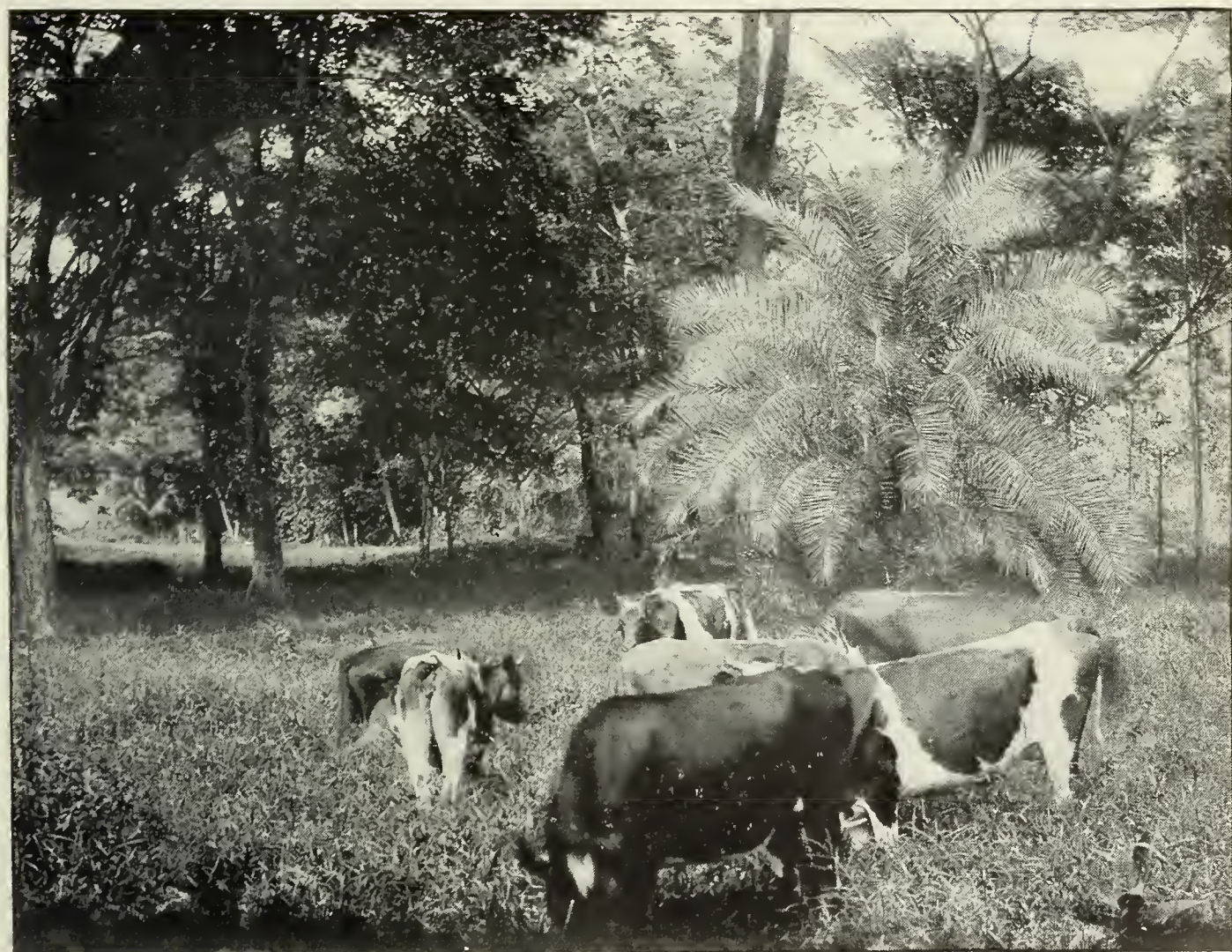
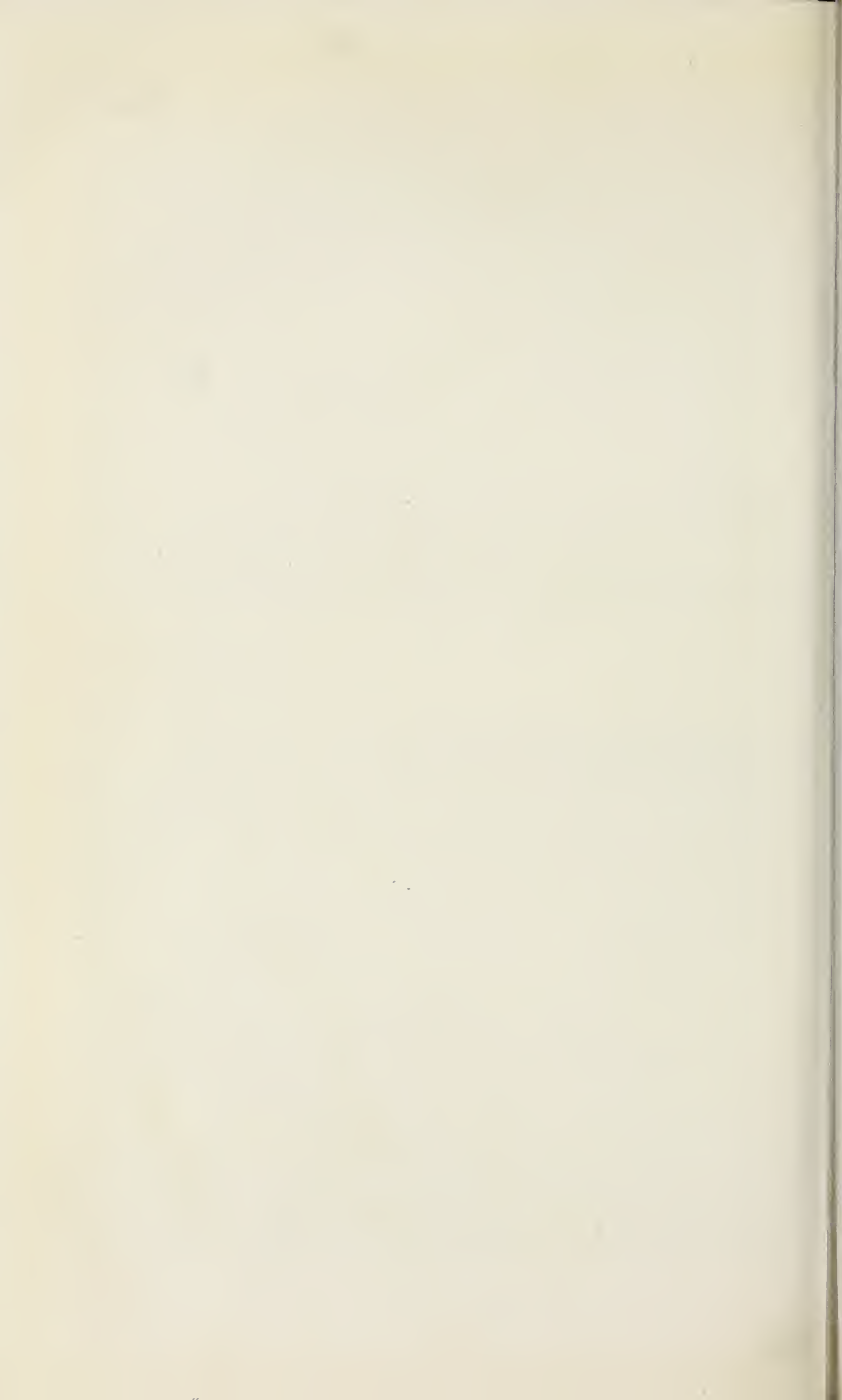


FIG. 2.—GUERNSEY NATIVE HEIFERS.



being built. The public is rapidly awakening to the wisdom of freeing the animals from the ticks and to the necessity of ultimately exterminating the pest altogether. As soon as enough tanks are available and the public is made to understand their value, so that a campaign to raise the necessary appropriation can be carried on, the elimination of the tick will be taken up and brought to a successful issue. From an agricultural standpoint, money could hardly be more wisely expended. Until the cattle tick is exterminated there will be no full development of the cattle industry, upon which the agricultural prosperity of the people of Porto Rico depends to a great extent. Porto Rico is a country that should produce not only for its own requirements but also for those of other countries, yet the dairy products imported during the fiscal year 1920 amounted to more than \$1,750,000.

FRUIT.

The amount of fruit exported during the year ended June 30, 1920, was approximately the same as in 1919, but the prices paid for it were somewhat higher, totaling \$2,645,000. The industry was affected by the lack of shipping facilities, and much fruit was lost because it was impossible to get it to market. When more pineapples are produced than can be marketed the fruit is usually handled to advantage by the canneries. A nonshipment of oranges, however, invariably results in great loss to the growers. This year Porto Rico produced a surplus of grapefruit, which was taken care of to some extent by a factory organized by the planters for bottling the juice.

The fruit industry has been developed since the American occupation; that is to say, within the last 22 years. In the early years of the industry it suffered considerably from exploiting companies which did not deal fairly with the investors. At present it is greatly handicapped by inadequate shipping facilities. Not only is the fruit delayed in being transported, but in many cases it is refused transportation because of lack of space on the steamers. The planting of fruits is greatly lessened at present, though its position as an industry is assured. The industry would be greatly furthered by a better cooperation among the growers. Efforts made to bring this about are proving successful. Closer cooperation will enable the planters to make a better study of their problems, secure better shipping facilities, and bring about better marketing conditions, which may result in greater appreciation of the quality of the fruit grown in Porto Rico.

One of the greatest handicaps of the fruit industry is the lack of uniformity and standardization of the product. Too many green pineapples have been shipped from Porto Rico. The Porto Rican

orange is still a nondescript. The wild orange is shipped in large amounts and is probably the type that is best known in the markets of the States. When cultivated fruit is shipped it has to compete with the wild fruit and suffer from the defects of the latter. Too much spoiled grapefruit has been exported from Porto Rico. This has resulted in loss in shipment and has helped decrease the price of good fruit. The fruit industry in Porto Rico has greatly suffered from the marketing of unripe fruit. Fruit that is produced before or after the normal season naturally brings a higher price than fruit that is grown in season. In an endeavor to reach this market many growers in Porto Rico have ripened their fruit by artificial means, or have given it the appearance of being ripe by sweating it. This process produces a beautiful coloring of the skin, but it does not make an unripe fruit edible. As a result of this deception, the value of the grapefruit has been lessened and its consumption has been greatly reduced. This practice was begun by only a few planters, but was soon followed by other growers who were attracted by the temporary profits it brought. Finally, at the solicitation of the planters themselves, a standard was established under the Food and Drugs Act for the purpose of stopping the shipment of immature fruit. It has not been very effective, however, owing to the difficulty of determining the standard and the hesitancy of applying the law in individual cases. The fruit growers of Porto Rico can not expect to obtain the profits that should accrue from the fruit industry unless they establish a good reputation and maintain it through honest cooperation.

TOBACCO.

The growing and manufacturing of tobacco was enormously increased during the year. The value of the exports of cigars, cigarettes, and leaf tobacco approximated \$25,000,000, more than half of which was for tobacco in the manufactured form. A distinct gain in the quality has been brought about by better cultural methods, and especially by improved means in curing and fermenting. This feature, together with the increased demand for tobacco everywhere, naturally has caused the price paid for it to be much higher than formerly. The industry is confined largely to certain interior valleys and surrounding hills. However, areas are being developed in other sections where tobaccos of fair quality are being produced. The industry is capable of great expansion, and many soil types may yet be found that will produce an excellent quality of leaf. A soil survey of the tobacco lands should be made, since it would no doubt result in greatly furthering the production of the crop.

COFFEE.

Of the coffee exported during the fiscal year 1920, \$8,769,000 worth went to foreign countries and only \$265,000 worth went to the States. The shipments were over 4,000,000 pounds in excess of the coffee exported in 1919. The average price received per pound was 27.6 cents, or an increase of 5.9 cents over the returns of the previous year.

The increased production of coffee was due largely to improved methods of cultivation and not to any great number of new trees coming into bearing. Though the year was considered a prosperous one for coffee, this industry has probably reached the zenith of its importance as a crop in Porto Rico. Owing to the ease with which it may be kept and marketed, the crop competes with the coffees of the most distant countries of the world. In Porto Rico the tendency is to grow crops bringing the highest prices in a market that can be reached within five or six days. On account of the proximity of the island to the eastern coast of the States, where most of its produce is sold, Porto Rico has less competition in certain perishables than other countries not so well situated. Nearness to market, therefore, gives perishable products an advantage over those than can be stored for a long time and transported over a long distance.

The most favorable outlook for the coffee grower is along the line of diversification. The time has passed when the planter could depend upon his coffee crop to bring him a large profit to meet his annual bills. He is continually faced with a decreasing production of coffee and a fluctuating and lowering market, as well as with direct competition with cheaper and more fertile lands. Moreover, since in certain of these coffee-producing countries the lands are undulating, the groves may be cultivated with plows; while the Porto Rican planter must continue to cultivate his mountain lands with the hoe or machete.

PLANT INTRODUCTIONS.

The station, in cooperation with other tropical stations and the United States Department of Agriculture, continued to introduce economic plants from various countries of the world. These cover a wide range, from varieties of plants of great economic importance to other plants that may prove of value for local consumption or exportation. Still others are for ornamental use only. The station has sought legumes that will improve the soil and provide forage for live stock, shade for coffee, and minor crops. A number of these are listed and described later in this report. Under forage crops

the velvet bean (*Stizolobium* sp.), sunn hemp (*Crotalaria juncea*, Pl. II, fig. 1), and Napier or elephant grass (*Pennisetum purpureum*, Pl. II, fig. 2) are worthy of extended planting. The elephant grass grows on low and high lands, can be cut several times during the year, and yields enormously. A recent cutting from a plat of four years' standing gave a yield of 12.8 tons per acre. A plat on high land cut for the first time 7 months and 10 days after planting yielded at the rate of 19.33 tons per acre. This grass is greatly relished by cattle and may be fed either as a soiling crop or pasture. Japanese cane will also be valuable as a forage crop. This cane is wholly immune to the mosaic disease and is being extensively planted for grinding for sugar. Even should more productive immune varieties be found, the Japanese cane will be invaluable as forage because it grows on high lands. Many of these lands are not planted now and produce only a meager amount of pasture.

The station is still sending out thousands of forest and ornamental trees, shrubs, and plants (Pl. III, figs. 1 and 2). While it is hard to estimate the value of this work, it is gratifying to note that the various introductions are benefiting and pleasing the people in all sections of Porto Rico.

The correspondence of the station shows a notable increase over last year's, especially in the matter of requests for information from planters in all parts of the island. The people are rapidly learning that the station is solely for their benefit, and that it stands ready to give them advice or suggestions on the various problems arising from time to time.

LIVING CONDITIONS IN PORTO RICO.

From the standpoint of beauty of surroundings and equable climate, country life in Porto Rico is ideal. The continued building of good roads and greatly facilitated means of communication between neighboring towns and villages has made life in all outlying districts much more attractive than formerly. Housing and living conditions generally have improved among plantation owners, but there is seldom, if ever, any change in conditions among the poorer classes.

Porto Rico continues to increase in population. The decennial census just closed reported a total increase of 15 per cent over the last census. At present there is an average of 377 persons to the square mile. In fact, the population has increased in numbers as fast as the agriculture of the island would permit. The actual wants of the laboring classes, or peons, as they are called, are few and simple, yet in many cases they lack the necessities of life.



FIG. 1.—CROTALARIA JUNCEA AS GREEN COVER CROP IN MANGO ORCHARD.



FIG. 2.—NAPIER OR ELEPHANT GRASS, 10 MONTHS' GROWTH.



FIG. 1.—INTRODUCED PALMS, CORYPHA, FISHTAIL, AND SUGAR PALMS.



FIG. 2.—EUCALYPTUS ROBUSTA, 8 YEARS OLD.

Labor is so plentiful in Porto Rico that laborers can not demand a living wage. Many of the plantations, especially in the interior of the island, are overrun with them, and often the plantation owners consider them a detriment rather than an aid. The peons construct on the plantations little shacks made from palm leaves or other local material. They pay no rent for the use of these shacks and often build them without the permission of the landowner. Public sentiment frequently looks upon the plantation owner as an oppressor, but in many cases he can do nothing to justify his paying a living wage to all the peons living on his place. They will not embark in ordinary farm practice, such as gardening or poultry raising, because of the fear that their produce will be stolen. The average laborer is not aggressive and can not well protect his own property and interests. Moreover, he is very hospitable and is as a result greatly imposed upon by relatives and friends. These people are practically tied to the plantation on which they live. They will not emigrate and they have no ambition.

The prosperity of the country has been dependent upon agriculture for five centuries, and no doubt will continue to depend upon it for many years to come. Porto Rico will hardly become a manufacturing country, because it has no coal and very little water power. Conditions have greatly changed throughout the island within recent years, but there is room for greater improvement. This can not be brought about, however, until the greater number of people now owning no land are better housed, fed, and clothed.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By L. G. WILLIS and J. O. CARRERO.

RICE INVESTIGATIONS.

During the year the greater part of the work of the chemical department dealt with the determination of the factors governing rice production. Special attention was given to the study of the relation of fertilizers and soils to the apparent physiological reaction of the plant. Many series of pot experiments were conducted, and the crops were analyzed where it was thought probable that the results would be of value.

It was found that potash is apparently not a limiting factor in the soils chosen for the work and that phosphates have a tendency under some conditions to cause a chlorotic condition of the plant due to faulty assimilation of iron. Since this observation was made on a basic soil only, it is probable that the added phosphate and the basic material in the soil were concerned in the production of chlorosis.

However, it is not certain whether the result was due to precipitation of iron in the soil or to interference with the normal distribution of iron in the plant. A difference was also noted in the response of the plant to different forms of phosphate fertilizer that is not explainable as being due to difference in availability. The different phosphates varied considerably in their tendency to produce chlorotic rice.

Tests of different forms of nitrogen for rice seemed to indicate that the results vary according to the reaction of the soil. Ammonium salts, except ammonium phosphate, were decidedly preferable for neutral or basic soils, and the nitrates gave the best results on acid soils. In practice, however, it is probably better to apply lime to acid soils in proportion to the degree of acidity, and to use ammonium sulphate as the source of nitrogen.

Determination of hydrogen-ion concentration in the extracts of the soils used in several pot experiments indicated that there is some intensification of acidity in the soil extract due to ammonium sulphate in comparison with that due to sodium nitrate. Phosphoric acid applied as such (H_3PO_4) to a basic soil gave good increases in yield. In case of acid soil the size and thriftiness of the plants increased with the amounts of phosphoric acid added, even though the actual acidity of the soil extracts (as shown by colorimetric hydrogen-ion determinations) was increased by such applications.

Apparently carbon dioxide was the acid most active in governing the soil reaction, since the hydrogen-ion concentration of the soil extract was lowered on exposure to the air, and iron and lime were precipitated.

Publication of the results thus far obtained in this investigation has been delayed on account of the complexity of the factors involved. It is hoped, however, to have results soon that will permit at least a preliminary report of the data recorded.

MANAGEMENT OF CANE SOILS.

The study of nitrogen economy in cane soils was carried on during the year as planned. It became necessary to relocate the plats after a preliminary test because the original area was not sufficiently uniform for the purpose of the experiment. However, the plats have now been laid out on the new tract, samples taken, and treatments applied, and the first green manure crop has been planted. This investigation is expected to yield quantitative results on the effect of lime, leguminous cover crops, different forms of nitrogenous fertilizers, and different methods of disposal of the cane residue on nitrogen utilization, conservation of soil organic matter, and soil reaction.

MISCELLANEOUS ANALYTICAL WORK.

Some analytical work was done for other departments of the station, including the analysis of over 300 seedling canes that are being tested by the plant breeder.

The department continued to make analyses of materials sent in from various sources when it was thought that the results would better general agricultural conditions. The greater part of this work consisted in testing cave deposits for their fertilizing value and soils for acidity. Recommendations were made as to the use of various fertilizers, the management of soils, and the application of lime.

REPORT OF THE HORTICULTURIST.

By T. B. McCLELLAND.

LEGUMES.

The variety tests of beans were continued, more than 40 distinct varieties being included and nearly 12,000 feet of bean rows being planted. These tests showed as a general rule that, under favorable conditions, much greater dependence for a crop can be placed on varieties previously grown in the Tropics than on those imported from the North. Both the Porto Rican white bean and the Venezuelan black bean are notable for heavy yields. Accidental crosses evidently have occurred in the field, and in many cases the progeny is being carefully watched. More than 500 selections were studied individually. Some of these appear very promising. White, straw, yellow, brown, pink, red, purple, and variegated beans developed from the Venezuelan black. Since the Porto Rican market objects to the black color of this very prolific bean and it is sold at a greatly reduced price as a result, it is hoped that something of value will be found among this lot when the pure lines are established. A very interesting case of variegation appeared in the plantings of Venezuelan black beans. On the same plant were borne some pods containing only straw-colored seeds, other pods containing only purple or lavender seeds, and still other pods having seeds of both colors. In some cases a single seed showed both colors. Other plants produced straw-colored seed only, or purple seed only, but it remains to be seen which of these breeds true to color.

Pigeon peas have been under test at the station for several seasons. When planted in the spring and picked green at frequent intervals from December to May, they yielded at the rate of 906 liters, weighing 1,246 pounds, per acre. A contemporaneous planting, in which the seeds were allowed to mature before picking, yielded at the rate

of 495 liters, weighing 900 pounds, per acre. A spring planting of the year following, in which only a single picking was made at the end of the season, yielded less than half as much as the preceding crop.

Seeds from plants producing green, mottled, and red pods were planted separately, yet a very mixed progeny developed, especially from the green-podded plants. The red-podded plants came much truer to color than the green-podded, though they were not entirely true. In a comparative test of native selections and a red-seeded variety received from Cuba, the former proved much more prolific than the latter.

For purposes of comparison a planting was made in March of several leguminous cover crops, including *Tephrosia candida*, *Canavalia ensiformis*, *Crotalaria juncea* (Pl. II, fig. 1), *Stizolobium velutinum*, *S. aterrimum*, and the bush velvet bean. At the end of 10 weeks all had developed a fairly good stand, the *Crotalaria* and bush velvet bean having made the best development. When the *Crotalaria* had reached a height of 4 feet, the *Tephrosia* measured only 7 inches or less in height. At the end of 17 weeks the *Crotalaria* began to blossom and stood 8 or 9 feet high, the bush velvet beans were 2 feet high, and the others were from 2 to 2½ feet high. The *Tephrosia* was extremely spindling at this stage, but in each of the other varieties representative sections of the field were cut at the surface of the ground and weighed. All rows were spaced 3 feet apart. The seed had been planted 8 inches apart in the row, except the *Crotalaria*, which had been closely dropped in the row. The green weights calculated to the acre were *Crotalaria juncea*, 12.6 tons; *Stizolobium velutinum*, 9 tons; *S. aterrimum*, 8.8 tons; bush velvet beans, 7.5 tons; and *Canavalia ensiformis*, 5.4 tons. After a period of 25 days, during which time plants were spread on trays and sunned, the weights were reduced to 3.0, 1.3, 1.4, 1.4, and 1.0 tons, respectively.

COFFEE.

The main lines of investigation followed in the past with coffee and cacao are still in progress. Robusta and closely related sorts of coffee have been very prolific in favorable locations and offer certain advantages over the locally-grown Arabian coffee. Sixty samples of Robusta coffee were sent to local consumers for cup testing. The opinion of the recipient was requested as to whether the coffee was considered of poor, medium, or good quality; inferior, equal, or superior to the Porto Rican coffee; and whether it should be planted in Porto Rico. Twenty-one replies were received, though some were incomplete. One consumer considered its cup-quality poor, ten consumers considered it medium, and ten good. Fourteen considered it

inferior; six, equal to, and one, superior to, the Porto Rican coffee. Nine thought it should be planted locally, and ten thought it should not be grown in Porto Rico.

About $2\frac{1}{2}$ years from the beginning of the cooperative experiment undertaken for the control of the coffee-leaf disease (*Stilbella flavida*) heretofore mentioned,¹ an overzealous foreman replanted a large part of the plat with badly diseased seedlings. As soon as this was discovered an attempt was made to remove as much of the diseased material as possible. Control measures, however, were rendered uncertain by these diseased seedlings. Up to this time they had been most effective.

VANILLA.

The 1917 vanilla crop from 0.1 acre planted in 1912-13 has been reported in detail.² The yield of each crop showed an increase over the preceding. In 1918 this increase amounted to more than 27 per cent, while the 1919 crop nearly equaled the total of the two preceding crops. The appearance of the vines suggests that the maximum yield has been reached and that much smaller crops from them are to be expected from now on.

The 1918 crop, cured and stored for a year from time of picking, was very favorably reported on by dealers to whom samples were submitted. Many considered it to compare favorably with the best cures on the market. It sold for \$3 a pound.

Experimental work in curing is being continued. Limitation of production continues to show a pronounced effect on the size of the bean. In a test of the effect on production of pruning the vine tips and of shading heavily, both the pruning and the very heavy shading reduced the crop in a 3-year-old planting. Where the supporting trees were kept closely pruned to allow as much sunlight as possible to reach the vines, the unpruned vines gave three times as great a crop as the pruned and densely shaded vines and more than twice as great a crop as where there was but a single variant factor, either heavy shading or pruning. On account of the frequent weeding, the unshaded plat required much more labor to keep it in order than the shaded plat, where weeding was unnecessary.

In January the horticulturist made a trip to Guadeloupe to study vanilla plantation and curing practices. Various plantations and the largest curing establishments were visited. Though there are some large plantations, the crop is produced mainly by small farmers. These men sell their produce green or partially cured to others who cure and export the beans. A common practice with plantation owners is to turn over a definite area to a laborer to plant. When

¹ Porto Rico Sta. Rpt. 1918, p. 11.

² Porto Rico Sta. Bul. 26 (1919).

the vines reach a producing age the laborer is paid an agreed sum. After receiving this sum, the laborer must turn in half the crop to the owner and sell him the other half at the prevailing market price.

The best beans were said to be produced at considerable elevations. One plantation ranged in elevation from 1,200 to 1,700 feet above sea level, and the owner preferred the beans produced on the higher parts of the plantation. The temperature was lower and the annual rainfall heavier than at this station.

Since the whole cluster is clipped at harvest time, many beans are removed before they have a chance to mature. This has a bad effect on the quality of the cured product. The preferred curing process consists mainly in alternate sweating, closely wrapping the beans in blankets, and fully exposing them to the sun when spread on blankets. Sweating vaults heated with steam coils are used to advantage in one establishment. The curing is finished indoors on airy shelves of wire screening.

MANGO.

In the past year the Fernandez mango, S. P. I. 19117, fruited for the first time in the station orchard (Pl. IV). Not only is it a beautiful and delicious fruit, but the lateness of its season adds to its value. Its crop ripened from mid-August to early October, when few or no other mangoes are to be had. At the beginning of the Fernandez season, Itamaracá and Sundersha were the only other imported varieties to be found in any quantity, but both had disappeared before the Fernandez season was over.

The general form of the Fernandez is ovoid; in cross section, round or slightly oval. The fruits examined weighed from 222 to 405 grams. The color is a marbled green and yellow, or a pale, dull, or greenish yellow, which becomes more intense near the base. The blush may be pink, rosy red, or bright orange red, and extends from over one-quarter to one-half of the fruit. The appearance of an otherwise beautiful fruit was marred by black or purplish disease spots and splotches, which were particularly numerous around the base. The skin is moderately tough and thick. It sticks so tightly that it breaks on peeling and tears the flesh of the fruit. The flesh is juicy and pale to medium yellow. Some fruits show fiber discolorations, but not actual fiber from a blackened base. The texture is good to excellent. The aroma is delicate but delicious and the flavor is sweet and somewhat peach-like. Were it not for disease the quality would be excellent. Very short, soft fiber is thickly set over the whole seed, giving it a woolly effect. It is too short to be objectionable, except on the basal half of the ventral margin of the seed, where the fiber is one-half inch long.

This variety was considerably affected by a disease causing blackening and rotting of the stem end and the formation of a cavity between the base of the seed and the base of the fruit. Provided it does not prove to be too much subject to disease, it will be a valuable acquisition.

MISCELLANEOUS INTRODUCTIONS.

Additions have been made to the avocado varieties already planted in the orchard on Las Mesas.

A small vineyard has been set with grape varieties found locally and with others introduced from the Virgin Islands.

Carica sp., S. P. I. 46321 and *Carica papaya*, S. P. I. 46334 were tested during the year. The former appears quite valueless as an edible and the latter is very insipid in taste, though it is a large fruit and makes a handsome appearance. Some fruits weigh more than 10 pounds (Pl. V).

The writer introduced two rather promising vegetables from Guadeloupe. One is a squash which is similar in shape to the vegetable marrow, but used when only 3 or 4 inches long. The other vegetable, Stringless Bonavist (*Dolichos lablab*), is a bean-like plant having broad, sweet pods similar to those of the English sugar peas. The pods are picked when young and cooked like string beans. Both of these vegetables seem acclimated.

REPORT OF THE ASSISTANT HORTICULTURIST.

By J. P. GRIFFITH.

VEGETABLES.

Practically all of the common vegetables of the Temperate Zone were tried out at the station in the course of the year. Those principally tested included tomatoes (12 varieties), onions (7 varieties), kohl-rabi, cabbage (3 varieties), collard, cauliflower, eggplant (3 varieties), pepper (5 varieties), cucumbers (3 varieties), lettuce (7 varieties), watermelons (4 varieties), muskmelons (4 varieties), squash (6 varieties) okra (3 varieties), Lima beans (2 varieties), peas, beets (4 varieties), carrots (4 varieties), turnips (2 varieties), radishes (4 varieties), sweet potatoes (7 varieties), sweet corn (6 varieties), Stringless Bonavist bean, Irish potatoes (3 varieties), peanuts (7 varieties).

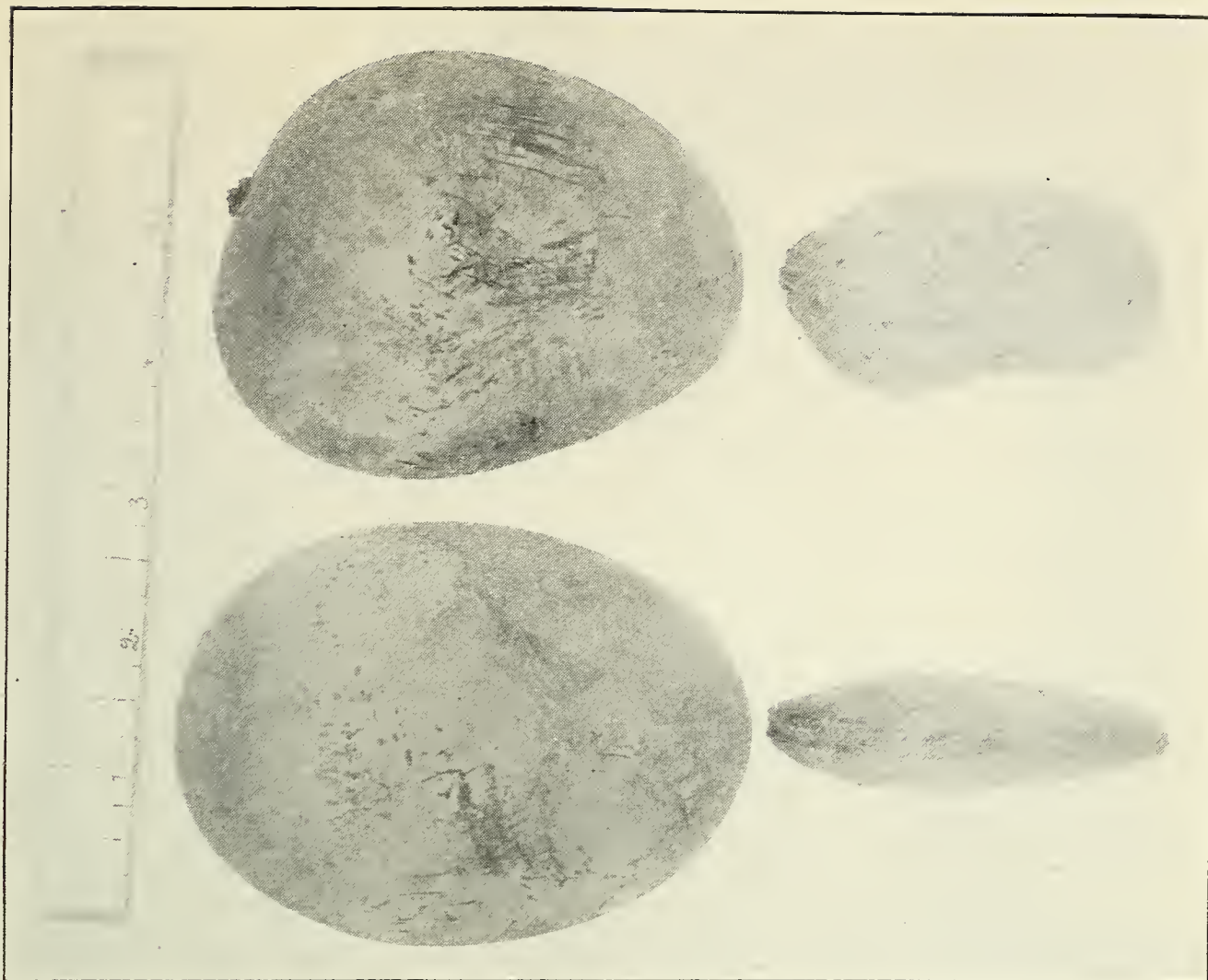
In addition to trials of these vegetables at the station, tests were made with most of them on a heavy loam soil a few kilometers north of Anasco. Some were planted also on the red spongy soil of the station's Mesa property.

Irish potatoes, broad beans, and peanuts have been growing since May 15 in the school garden at Maricao, which is 1,500 feet above sea level. The soil there is a clay that has been considerably lightened by heavy applications of manure. The Early Rose potato was the variety planted. On July 30 the condition of the crop indicated that it would be ready to dig within three weeks' or a month's time. The yield of three hills was one-half peck. The potatoes, of course, were not fully mature, but their shape was first-class, and they were free from disease and of splendid quality. The haulms were well grown and showed no signs of insect or disease injury. Peanuts, the seed of which was secured from Washington, D. C., were growing very well. Two varieties of broad beans from England were also promising. Seeds of the broad beans were harvested at the station last winter. The plant growth was very good, although late in the season the foliage showed signs of burning and the flowers blasted to some extent. It would seem, therefore, that the lowlands are too hot for this crop.

During the winter months the most successful vegetables grown at the station were tomatoes, cabbage, collard, eggplant, pepper, lettuce, squash, okra, Lima beans, beets, carrots, radishes, sweet potatoes, and peanuts.

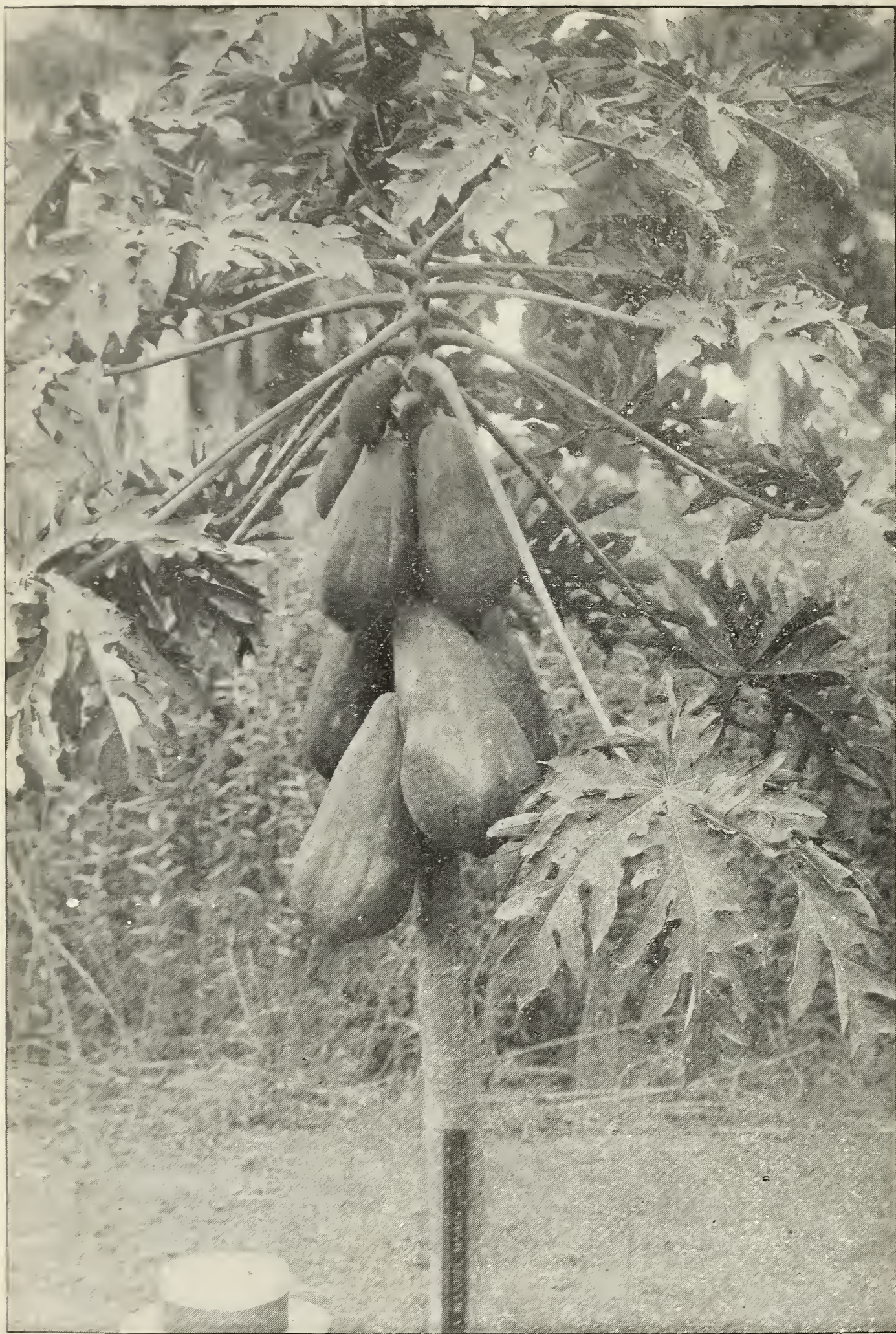
Tomatoes.—Prolific and Sugar Cream, two California tomato hybrids, made very vigorous growth during the year. These plants were grown from seed produced in Porto Rico. Wilt, which was the most serious disease attacking the vegetables at the station, invariably cut the crop, because the plants died when the set of fruit was heaviest. Seed of five wilt-resistant varieties, Marvel, Norton, No. 324, Arlington, and Columbia, were secured from Washington, D. C., and the Ohio Experiment Station. These, together with Tomato No. 443, bred by the insular station at Rio Piedras, offer favorable opportunity for the production of an acclimated, resistant, and prolific variety for Porto Rican conditions. Trials at the station showed Tomato No. 443 to be a vigorous grower and a good producer. The fruit, however, lacks size and shape. It is by no means uniform. Pear-shaped types, smooth types, and much ridged kinds resembling the native fruit are all in evidence. This variety is the result of a cross between the Livingston Globe and the native cherry tomato. The vine growth of the latter has been strongly inherited.

During the year the station started a project having for its object the production of a vigorous growing, heavy yielding tomato which would bear large, smooth fruit. Insular Station Tomato No. 443 was used as the foundation stock. The seed was planted on April 26, 1920, and grew vigorously. On May 29 the plants were set in the field, and on June 30 they fruited. Cutting selections were made



FERNANDEZ MANGO (S. P. I. No. 19117).





CARICA PAPAYA, ONE YEAR FROM SEED (S. P. I. No. 46334).

from two of the best plants and bedded in sand on July 14. These were potted on July 29. Selections (by cuttings) from three other promising plants were made on July 29 and August 6. A few cuttings were also made of the Diener, a California tomato. These cuttings are to be grown to maturity in the greenhouse and crosses made from them. Tomato seedlings are also being raised. Plants will be grown from these seedlings by setting them in the field in late fall. Further crosses can be obtained when these plants mature. In this way the work will be continued.

On the Mesa, the Dwarf Champion tomato was much ahead of any others tested. In fact, this variety was the most successful of any tested during the past year. It was prolific and practically free from disease until very late in the season.

Cabbage and collard.—Cabbage and collard produced good crops during the past season as a result of having received much fertilizer and plenty of water. Early Jersey Wakefield did very well.

Eggplant.—The varieties of eggplants tested at the station this year were New York Improved, Black Beauty, and Florida High Bush. The plant growth of Florida High Bush was most desirable, though its fruit lacked size. The plant growth of the New York Improved and Black Beauty was so low that the fruit rested on the ground. All three varieties made good yields, both at the station and on the Mesa. The native eggplant is a very tall grower. It should, therefore, produce a good type if crossed with a variety having larger fruit.

Peppers.—Peppers grew very well at the station. Some selections were made from the most promising plants. Two hot varieties and three sweet ones were tried out.

Lettuce.—The greatest advance of the year in lettuce was the successful production of a heading type. This was the Mignonette, a small head lettuce having reddish tinged leaves. Very solid heads were formed, apparently because of rapid growth resulting from heavy fertilization. The loose-leaf types are grown widely over the island because they are easily produced.

Squash.—Squash was the best of the station's cucurbits. It was one of the three or four completely successful vegetables at Anasco, in spite of the fact that only commercial fertilizer was used on the ground where it was planted. Small summer squashes grew very well. Vegetable Marrow and Mammoth Chile were superior varieties. A native squash was also grown alongside for comparison. All varieties did well at the station.

Okra.—Okra was another of the best vegetables on trial at Anasco. The three varieties raised there were much better than any grown in the station garden. Dwarf Prolific and White Velvet did very well. The native okra, however, seems satisfactory for all purposes.

Lima beans.—The season was very favorable for Lima beans. The crop produced from American seed was a good one, owing to a dry spell that set in when it began to mature. The Fordhook Bush and Dreer's Bush bean were the best of their class. Small Lima beans such as Henderson's Bush did not thrive. The Leviathan pole bean grew very well and continued bearing until late in the spring.

Carrots and beets.—Carrots and beets were not successful at Anasco, but did very well at the station. All four varieties of carrots gave good yields, though French Forcing, Oxheart, and Danvers did better than Chantenay. Of the beets tested, Crosby's Egyptian was superior.

Radishes.—Radishes did exceptionally well at Anasco, and results from three crops at the station were all that could be desired. Radishes have been grown commercially in Porto Rico for many years. They are, perhaps, the easiest of all vegetables to produce here.

Sweet potatoes.—The horticulturist at the North Carolina experiment station sent this station tubers of seven of the most popular sweet potatoes in that State. Five of these grew well at the station, the variety Hayman being the most promising, judging from the quality, total yield, and shape of the tubers. Thirty-five varieties supplied by the Bureau of Plant Industry, United States Department of Agriculture, are now under test in the field.

Irish potatoes.—Of the two varieties of Irish potatoes, Cobbler and Bliss Triumph, the latter did best at the station. These potatoes were grown during the winter months and produced strong, disease-free tops. When dug, however, they were disappointing, only little more than the seed planted being returned. The Early Rose potatoes, planted at the station at the same time (May 15) as those at Maricao, were a complete failure.

Peanuts.—Two varieties of peanuts, Jumbo and Virginia Bush, did very well at the station. Tests of these varieties on the sandy soil of the beach were also successful.

Corn.—Sweet corn was tried at the station and on the Mesa farm. From a small planting at the latter place a dozen fairly good ears were secured. Worms finally destroyed the crop. Should another planting of sweet corn be made at the Mesa farm, measures will be taken to control the worms. A planting in the station garden was a failure, not a single ear of corn being picked. The early season was very dry, and conditions were strongly unfavorable for planting.

Cucumbers and muskmelons.—Rust killed cucumbers and muskmelons early in their growth. Aphids on the under leaves also hindered the growth of these plants. Watermelons grew well until the fruit crop began to draw heavily on the vines. The latter did not

have the strength to mature a crop. Two or three nearly mature melons were secured.

Kohl-rabi and onions.—Kohl-rabi was a success. Onions produced from seed, seedlings, and from sets yielded bulbs averaging 2 to 3 inches in diameter.

REPORT OF THE ENTOMOLOGIST.

By W. V. TOWER.

BEEES.

The past year was one of the hardest years that beekeepers in Porto Rico ever experienced. Reports from all parts of the island tell of severe droughts, and the small amount of honey stored. Honey brought a fair price, however, and should continue to pay well as long as sugar is high.

Records were kept of honey production (Pl. VI, fig. 1) and of the blossoming period of the various honey trees.

MOSQUITOES.

During the year a survey was made of the mosquitoes infesting Mayaguez. Mosquitoes were very troublesome at the station and throughout town. Eight species were found, including the malarial mosquito.

TICKS.

During the last six months of the year 1,500 cattle were dipped in the dipping tank at the station. Previous to this time no records were kept. Every three weeks the solution in the tanks is brought up to the standard either by adding chemicals to increase its strength, or by adding water to dilute it. Cattle owners are advised of this in order that they may promptly send in their animals for dipping.

Insectary work with ticks was continued. During the very dry winter months it was difficult to keep the various lots of ticks alive. Not much trouble was experienced in this regard during the rainy season. Studies were carried on with ticks taken from horses, dogs, and goats.

SCALE INSECTS.

For the past few years the purple scale in the citrus groves has been held in check by various beneficial fungi which prevail where windbreaks are employed. Very little spraying has been done in old orchards, though it has been practiced in new orchards.

The white scale increased the past season on account of the very dry spring and summer. This scale is worse in young groves planted

in light sandy soils than elsewhere. It has fewer species of beneficial fungi preying upon it than the purple scale, and it does not respond so readily to treatment.

The Florida scale has not been found in the groves for a number of seasons, though an occasional small infection has been observed at the station.

The rufous scale has been found a number of times in the groves and also on the fruit at the station during the past season. Should it become abundant, it may be brought under control by the use of the following formulas, which were found very effective in Florida:¹

Cold-stirred emulsion.

Fish-oil soap:

By weight-----	pounds--	8
By measure-----	gallon--	1
Paraffin oil 24° or 28° Baumé-----	gallons--	2
Water-----	gallon--	1

Boiled emulsion.

Paraffin oil-----	gallons--	2
Water-----	do-----	1
Fish-oil soap-----	pounds--	2
or		
Hard soap-----	do--	1

CITRUS SCAB.

In December, 1919, a grove at Palo Seco was platted and notes were carefully made showing the amount of scab present. This grove has always produced very scabby fruits, sometimes yielding as high as 90 per cent infected fruit. At the present time the grove is divided into four plats, each of which is receiving different fertilizers. Scab seems to follow heavy applications of nitrogen. A marked difference in the amount of scab is noted in certain parts of the grove. The south side, for instance, which did not get as much sun as the north side, showed a heavier infection of scab. Less scab was found where the production was the heaviest.

It would seem that an excessive application of nitrogen renders the tree susceptible to infection. If this is the case, it would be advisable to keep the trees in good condition throughout the year instead of giving them one heavy application of nitrogen just before blossoming time. It has been the practice of many growers to make

¹ Those especially interested in spraying for the control of insects may find valuable information by referring to Farmers' Bulletin 933, Spraying for the Control of Insects and Mites Attacking Citrus in Florida, which can be obtained by applying to the United States Department of Agriculture.

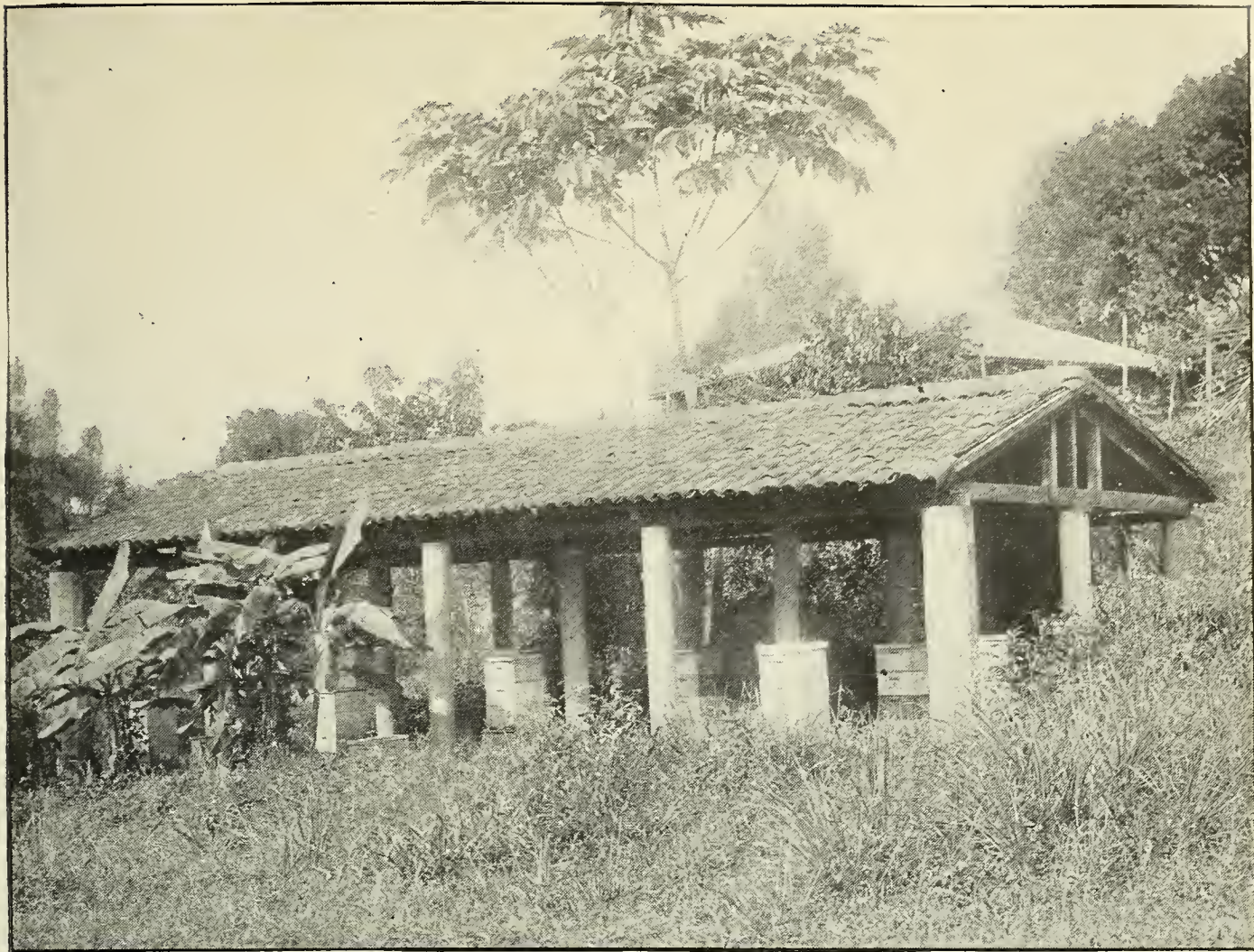
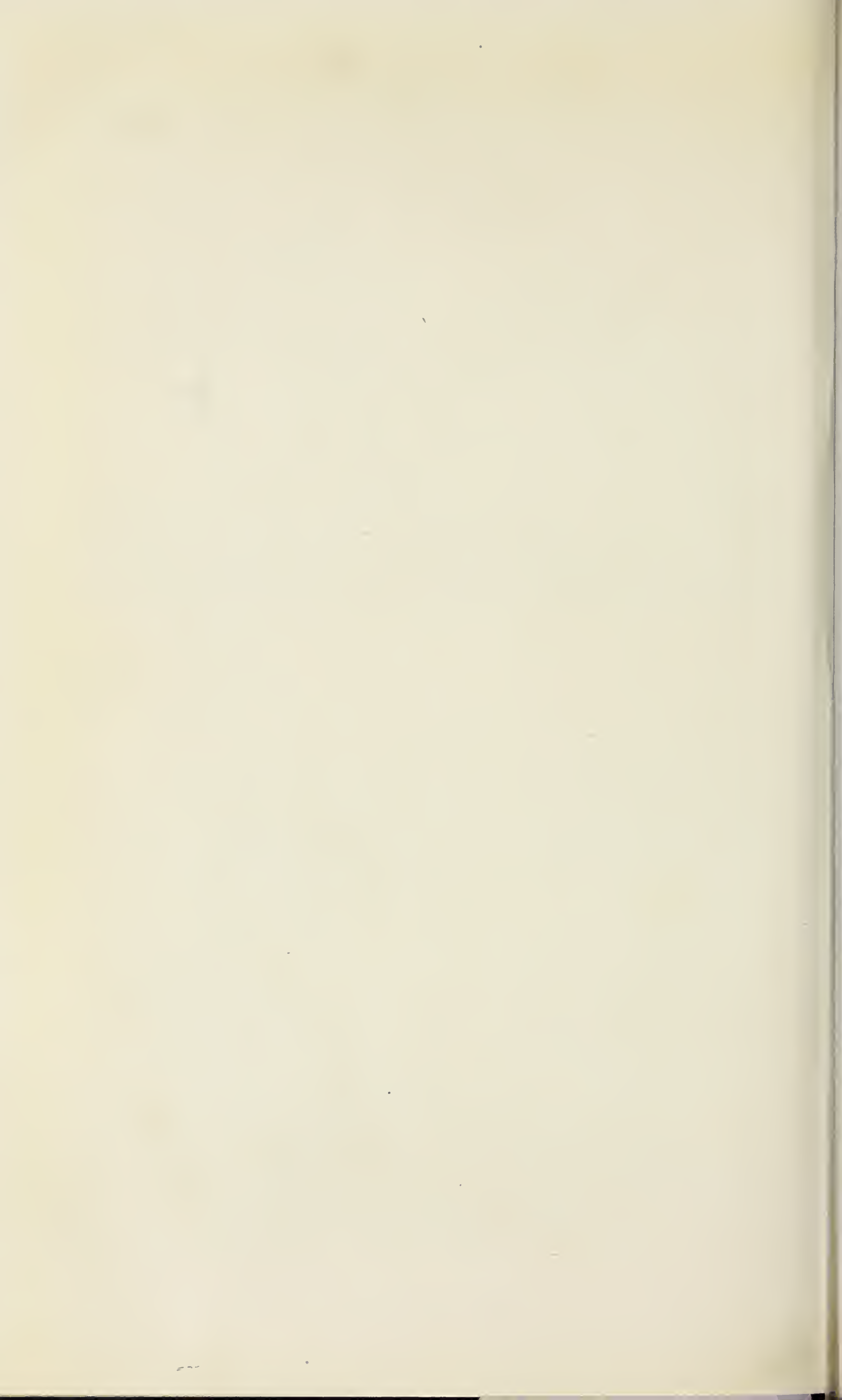


FIG. 1.—STATION APIARY.



FIG. 2.—KAVANGIRE, A JAPANESE CANE IMMUNE TO MOSAIC DISEASE;
10 MONTHS' GROWTH.



one application of fertilizer during the spring. This is done as soon after picking as possible, when the soil is in condition to plow. The plowing generally starts growth, and a heavy application of nitrogenous fertilizer produces a heavy, succulent growth. This fertilizer could be applied during the growing season, but it should not be used in hurtful quantities or at times when it would have any bad effect on the hanging fruit. Two or more small applications would, no doubt, be more advisable than one large application just at blossoming time.

WINDBREAKS FOR CITRUS.

The growing of windbreaks has been carried on for many years in Porto Rico, and the growers have profited by it. At present there is a tendency to plant more leguminous plants and trees for windbreaks. Among quick-growing kinds, the pigeon pea, *Agati grandiflora*, and *Crotalaria juncea* can be used as temporary windbreaks. The bamboo is being replaced by the bucare, guava, and guama trees for permanent windbreaks. It has frequently been noted that citrus trees become very thrifty and bear well when planted near the bucare tree. Too dense a shade from this tree tends to lessen production, though a reasonable amount of shade seems to be beneficial to the citrus. The planting of leguminous trees as windbreaks should be encouraged because they do not rob the trees as the bamboo does. Where bamboo is planted, the first and second rows of citrus trees often suffer and are never equal to the other rows because of the encroachment of the bamboo roots. The bamboo, however, is excellent in places where winds are very heavy because it bends without breaking.

MULCHING CITRUS.

Cane trash was applied as a mulch to a number of rows of trees in February, 1920. Other rows were left without treatment. The grove was taken care of in the usual manner, the centers being cultivated with a disc. In June most of the trees that had received a good mulch of cane trash showed a white bloom. Those without mulch were showing only a scattering bloom.

COVER CROPS FOR CITRUS.

Numerous plantings of sunn hemp (*Crotalaria juncea*) were made at the station (Pl. II, fig. 1), and those grown among the citrus trees were very promising. Strips of sunn hemp were planted in a grove on April 21, and two months later they were cut, their height then being 6 or 7 feet. The weight, including roots, per acre, is shown in Table 1.

TABLE 1.—*Calculated weight of sunn hemp per acre.*

Section of plant.	Green weight.	Air-dry weight.
	<i>Tons.</i>	<i>Tons.</i>
Stems, leaves, and roots.....	13.62	2.84
Stems and leaves.....	11.93	2.48
Roots.....	1.69	.36

The entire crop was thrown under the trees as a mulch. The leaves rotted in a very short time, and in about one month had disappeared, leaving only the soft, pithy stems.

On June 8, when the *Crotalaria* was about 3 or 4 feet high, part of a plat was topped at different heights, and later 2 to 6 branches developed from these plants. On August 5, 105 days from date of planting, these branches were cut and the green weights were taken. Table 2 gives the weights.

TABLE 2.—*Green weight of branches of Crotalaria topped at different heights.*

Num- ber of plat.	Height when topped.	Yield per acre.	Height when cut.
		<i>Tons.</i>	<i>Feet.</i>
1	Check; not topped.....	29.62
2	Topped at 12 inches.....	10.67	8½
3	Topped at 24 inches.....	22.49	9
4	Topped at 30 inches.....	23.95	9½
5	Topped at 42 inches.....	27.87	10½

This crop is new to the island and at present only two species of insects are found feeding on it. One of these is a small snout beetle which feeds on the young, tender pods. The other pest is the larvæ of a small butterfly that cuts small round holes in the pod, through which it enters and cuts the seed. The larvæ in the first stage are covered with hairs and are black and yellow, the black predominating. In the later stages the yellow predominates, and the long hairs disappear. A few of the larvæ were found completely enveloped in fungus. A number of seeds had been eaten, but the insects were destroyed before reaching full development. The fungus resembled that which works on the cane moth stalk-borer. The holes are generally near the top of the pod, where it is attached to the plant, and on the underside, where it is protected from the rain. The adult butterfly is very handsome, having pink wings with white circles and black dots in the centers. The head and thorax are white with black markings.

During a wet period snails ate the leaves on the stalks to a height of 5 feet. This was in a very thick planting where there was not much light.

INFLUENCE OF FERTILIZER ON QUALITY OF FRUIT.

On the Dreier farm certain plats in the grapefruit grove received different applications of nitrogen and potash. The nitrogen plats were dark green; those that had the same amount of nitrogen plus a large amount of potash were very yellow. The nitrate plat receiving no potash showed 45.9 per cent fancy fruit and 54.1 per cent ordinary fruit. The potash plat showed 75.3 per cent fancy fruit and 24.7 per cent ordinary fruit. Practically no difference was observed in size of fruit or in yield. The yield for the first picking averaged $7\frac{1}{2}$ packed boxes per tree, which is very high. Regarding holding qualities, the plat that received the potash had the smallest number of dropped fruits and the fruit seemed to be holding better. Reckoning on the high market prices of 1919, the potash plat would show a gain of 30 cents per box, or \$2.10 per tree, in favor of the potash. On the low market prices of this past year there was a difference of 12 cents per box, or 90 cents per tree.

SHADE FOR CITRUS TREES.

Observations were made during the year on two groves of citrus trees that have been growing under guava (*Inga vera*) shade. The fruits in the grove in the vicinity of Mayaguez were all borne singly and were very handsome, having kid-glove skin which was free from scab. The fruit on trees in the open was scabby and in clusters and far inferior to that in the shade. The same conditions were found in the other groves. The fruit on all trees growing in guava shade seems to be less in amount than on trees growing in the open.

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. HENRICKSEN.

THE FRUIT INDUSTRY.

The general survey of the fruit industry, which was planned in 1917 and interrupted by the war, was again taken up this year. The work in connection with citrus fruits has been segregated into five projects with aims as follows: (1) To study the influence of soil, environment, and cultural treatment on stock and variety, measured by the size and health of the tree and the quality and quantity of the fruit it produces; (2) to determine the varieties that have become established in Porto Rico, as well as to select the most desirable types and to eliminate the undesirable ones; (3) to determine the

present cost of producing and handling fruit in Porto Rico, and to devise methods of reducing the cost; (4) to compare the fruit produced here with that produced elsewhere in regard to quality and quantity, method of packing, time of maturity, distribution and marketing, price received, and cost of production and handling; and (5) to obtain data on decay of fruit in transit, and to find methods of preventing this decay.

Projects 1 and 2 include work that will have to be carried on for several years before any definite results can be obtained. Much valuable information is being collected relative to all of these projects, and whatever is found to be of special interest is given out from time to time for use by the planters.

COST OF PRODUCTION.

It was found impossible to obtain accurate data on cost of production. The figures indicate that it is seldom less than \$1 per box for citrus fruit, and that it is very frequently as high as \$2 per box.

COST OF HANDLING.

The cost of handling fruit was studied in detail and data covering this work for the past 10 years have been tabulated. The packing-house costs vary according to the size of the house and the amount of fruit packed. Table 3 shows the average cost of handling fruit under the most favorable conditions. About 75 per cent of the fruit shipped from Porto Rico has not been packed under such conditions, however, and the cost has been from 25 to 40 per cent higher.

TABLE 3.—Average packing cost per box for plantation packing houses.

Kind of fruit.	Labor.	Boxes.	Paper.	Nails.	Straps.	Cleats.	Total.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Grapefruit:							
1910-1913.....	13	20.5	4.0	0.3	1.5	0.5	39.8
1914-1917.....	13	23.5	5.3	.6	2.0	1.0	45.4
1918-1919.....	13	36.5	7.0	.8	3.0	1.5	61.8
Oranges:							
1910-1913.....	15	20.5	6.0	.3	1.5	1.5	43.8
1914-1917.....	15	23.5	8.0	.6	2.0	1.0	50.1
1918-1919.....	15	36.5	13.5	.8	3.0	1.5	70.3
Pineapples:							
1910-1913.....	13	20.5	5.0	.4	1.5	.5	40.9
1914-1917.....	13	23.5	7.0	.9	2.0	1.0	47.4
1918-1919.....	13	36.5	9.0	1.5	3.0	1.5	64.5

The cost of labor has not been stationary, as would appear from Table 3. During the 10 years previous to July, 1919, wages for fruit plantations rose about 33 per cent for women and boys and 45

per cent for men. The increased efficiency of the laborers about offsets the rise in wages up to July, 1919, but it is questionable whether this is true to-day. The increased packing-house cost is due chiefly to the increased cost of materials, which amounted to about 60 per cent during the 10-year period.

Table 4 shows the total cost of handling a box of fruit from the time it is picked in Porto Rico until it is placed on sale in the auction room in New York. Very little of the fruit has been handled at a cost cheaper than that given in the table, and on at least 50 per cent of it the handling cost per box has been from 15 to 25 cents higher than the figures given. In 1919, for instance, it cost from \$1.40 to \$1.70 to pick a box of grapefruit and place it in the auction room in New York. The fruit is sold on a commission basis ranging from 6 per cent up, and therefore a box of fruit selling at auction for \$3 will be charged 18 cents or more commission. That, together with \$1.40, the minimum handling cost, deducted from the price, will leave \$1.42 to pay the production cost.

TABLE 4.—*Total handling cost of fruit per box.*

Kind of fruit.	Picking.	Packing-house cost.	Transportation to wharf.	Ocean freight.	Miscellaneous charges. ¹	Total handling charges.
	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>	<i>Cents.</i>
Grapefruit:						
1910-1913.....	5.5	39.8	13	30	5.0	93.3
1914-1917.....	5.5	45.4	14	30	6.0	100.9
1918-1919.....	5.5	61.8	15	50	6.5	138.8
Oranges:						
1910-1913.....	7.0	43.8	13	30	5.0	98.8
1914-1917.....	7.0	50.1	14	30	6.0	107.1
1918-1919.....	7.0	70.3	15	50	6.5	148.8
Pineapples:						
1910-1913.....	7.0	40.9	13	35	5.0	100.9
1914-1917.....	7.0	47.4	14	35	6.0	109.4
1918-1919.....	7.0	64.5	15	55	6.5	148.0

¹ Miscellaneous costs include dock inspection, marine insurance, and cartage and labor in connection with auction samples.

SOME OF THE FACTORS INFLUENCING PRICE.

A great many statistical data comparing fruit production in Porto Rico and other countries have been gathered locally, but comparative figures are still wanting from countries with which Porto Rico must compete.

Table 5, based upon figures obtained from the Porto Rico Fruit Exchange, illustrates the influence of time and shipment upon the price of the fruit.

TABLE 5.—Average percentage of fruit shipped monthly from Porto Rico and the average price and returns after the handling cost has been deducted.

GRAPEFRUIT.

Month.	July, 1910, to June, 1914.			July, 1914, to June, 1917.		
	Proportional shipment per month.	Average monthly selling price in New York.	Returns after deducting handling cost.	Proportional shipment per month.	Average monthly selling price in New York.	Returns after deducting handling cost.
	<i>Per cent.</i>			<i>Per cent.</i>		
July.....		\$2.93	\$1.82		\$1.96	\$0.83
August.....		5.21	3.97		2.60	1.43
September.....	2.1	4.53	3.33	2.6	3.16	1.96
October.....	5.5	3.71	2.56	12.2	2.95	1.76
November.....	8.1	2.53	1.45	19.0	2.07	.93
December.....	9.5	2.35	1.27	13.0	1.48	.38
January.....	15.9	2.79	1.69	11.0	1.79	.67
February.....	21.6	2.24	1.17	16.0	1.58	.47
March.....	18.4	2.50	1.42	13.5	2.04	.90
April.....	13.7	2.19	1.13	8.8	2.39	1.22
May.....	4.7	2.88	1.78	1.8	1.76	.64
June.....	1.5	3.30	2.17	1.0	2.04	.90
Average annually.....		2.61	1.52		2.05	.91

ORANGES.

July.....						
August.....		\$1.54	\$0.46		\$1.43	\$0.27
September.....		2.45	1.32	0.3	1.34	.19
October.....	3.5	2.25	1.13	4.0	2.04	.85
November.....	11.3	1.55	.47	23.4	1.66	.49
December.....	16.5	1.41	.34	24.2	1.38	.23
January.....	22.6	1.35	.28	17.8	1.63	.46
February.....	20.4	1.57	.49	13.0	2.05	.86
March.....	14.2	1.96	.86	12.6	2.08	.89
April.....	7.8	1.69	.60	4.2	2.17	.97
May.....	1.4	2.19	1.07	1.7	1.73	.56
June.....	1.5	2.42	1.29	.8	1.38	.23
Average annually.....		1.51	.43		1.78	.60

PINEAPPLES.

July.....	6.0	\$5.28	\$3.96	5.1	\$1.82	\$0.62
August.....	2.5	1.88	.76	3.0	1.81	.61
September.....	1.5	2.13	1.00	2.1	2.01	.88
October.....	1.4	2.28	1.14	1.3	2.22	1.00
November.....	2.3	1.89	.77	3.2	2.23	1.01
December.....	2.7	1.76	.64	5.2	1.53	.35
January.....	2.5	1.98	.85	2.8	2.03	.82
February.....	1.7	2.32	1.17	1.9	2.84	1.58
March.....	5.3	3.06	1.87	3.8	3.02	1.75
April.....	21.7	2.29	1.14	17.5	2.50	1.26
May.....	37.3	1.71	.60	36.9	1.78	.58
June.....	14.5	1.87	.76	16.1	1.70	.51
Average annually.....		1.97	.84		2.01	.80

Data are shown for two periods—July, 1910, to June, 1914, and July, 1914, to June, 1917—because of the differences in handling cost as well as in selling price during these periods. Figures were compiled for three periods, but inasmuch as the data for the last period are not complete at this time no statement can be made concerning them. Regarding time of shipment, the months of July and August need not be considered in the case of the citrus fruit because less

than 1 per cent of the total fruit is shipped during these two months. The price of grapefruit is always high during the months of September and October, but only a comparatively small quantity is mature enough for shipment then. The quantity of oranges maturing before November is still smaller, but the October price is as a rule higher than that of any month later. After November 15 the price of oranges and grapefruit fluctuates according to the quantity reaching the market from elsewhere. The bulk of the fruit is shipped between November 15 and April 15. The market is too frequently glutted at this time, because the bulk of the Florida and Cuban fruit is also shipped then. The condition is reversed in the case of pineapples. The months of February to April, inclusive, are the most profitable for shipping this fruit. However, the quantity maturing then is small. For many years the bulk of the fruit was shipped between May 15 and the first week in June, and a sharp break in prices always occurred between May 15 and 20. During the last three years the crop has been short, and conditions in prices have changed. Under the heading "Returns after deducting handling cost" in the table is shown the average amount of money per box left over after the handling cost has been paid and the 6 per cent commission for selling has been deducted.

The annual shipments of citrus fruit and pineapples during the past 11 years are shown in Table 6.

TABLE 6.—*Annual shipments of fruit from Porto Rico since 1910.*¹

Year ending June 30.	Grapefruit.		Oranges.		Pineapples.	
	Number of boxes.	Value.	Number of boxes.	Value.	Number of boxes.	Value.
1910.....	48,441	\$162,749	296,058	\$582,716	277,058	\$555,044*
1911.....	96,189	309,698	349,442	703,969	335,641	641,291
1912.....	118,937	525,048	277,422	584,414	319,096	684,774
1913.....	216,247	726,811	353,690	740,091	360,288	1,142,348
1914.....	206,200	751,769	348,927	752,180	369,952	1,246,001
1915.....	276,583	834,440	200,311	378,181	552,085	1,723,863
1916.....	296,645	837,014	404,451	790,797	532,259	1,176,406
1917.....	435,890	939,677	503,318	1,009,737	416,550	916,415
1918.....	549,125	1,120,330	603,226	1,231,551	145,605	617,496
1919.....	417,369	739,106	373,679	770,303	116,000	458,675
1920.....	419,629	1,332,742	336,625	833,575	140,906	479,461

¹ The figures were taken from the customhouse records, and the values are therefore according to shipping declarations and not according to the actual price received.

Most of the citrus fruit is packed under five grades. Some houses pack under four grades, but most houses employ an extra grade when occasion demands.

Table 7 shows how the prices of the five grades compare with one another; it also shows the percentage of each grade shipped, and the net return after all the handling costs are paid at the rate of \$1.50 per box, plus the commission of 6 per cent for selling.

TABLE 7.—*Prices as influenced by grades at the Porto Rico Fruit Exchange during the season of 1918-19.*

Kind of grapefruit.	Proportional shipment of boxes from Porto Rico.	Average price received per box.	Handling cost per box. ¹	Returns after deducting handling cost.
	<i>Per cent.</i>			
Blue Ray.....	1.75	\$5.36	\$1.82	\$3.54
Red Ray.....	19.36	4.37	1.76	2.61
Purple Ray.....	41.00	3.83	1.73	2.10
Bronze Ray.....	12.42	4.20	1.75	2.45
Suniface.....	25.45	2.89	1.67	1.22

¹ In handling cost the average figure of \$1.50 per box has been used as a basis, plus the commission of 6 per cent for selling.

It is readily apparent from Table 7 that the high prices received for grapefruit in 1918 to 1919 would not only pay the cost of production, but also leave a safe margin for profit. Unfortunately, however, conditions are not always so favorable. The principal difficulty lies in the shipment of a large percentage of low-grade fruit. This difficulty is being overcome by using the low-grade fruit for marmalade and its juice for bottling as a beverage. The highest grade of fruit amounts to less than 2 per cent of the total grapefruit shipped, as shown by the figures in Table 7. This is a difficulty that has yet to be overcome. The problem to be solved is to find a means by which some of the fruit in the lower grades can be raised to that of the next higher grade. It will be observed that the difference in price between any two adjoining grades ranges from 93 cents to \$1.44, and a grower can well afford to spend 50 cents or more per box to raise a lower grade of fruit to a higher one.

Grapefruit is packed in 10 sizes, ranging from 28 to 150 in a box. The two extreme sizes usually amount to less than 0.5 per cent each of the total shipment and the price is seldom satisfactory. There is sometimes a fair demand for the 28's and 36's during the early part of the season, though they may be unprofitable later. The five sizes 46 to 96 are the most profitable, and about 90 per cent of the total ranges between these extremes, varying of course from year to year.

Pineapples are packed in 10 sizes ranging from 16 to 64 in a box. Nowadays only a very small percentage reach a size larger than 24. In 1918 about 10 per cent of all the fruit was packed as 54's and 64's, but the price on these sizes is frequently too low to be profitable. In pineapple growing the problems are how to produce large fruit, how to produce enough slips to maintain the fields, and how to maintain the land in a condition to produce profitable crops. These problems are being studied, but no report can be made concerning them at this time.

FRUIT ROT.

A study of decay in transit and its prevention was started in response to a request from the fruit growers. As a beginning, all available data were tabulated; the amount of decay was shown as reported by the receivers in New York, the individual grower, the house in which the fruit was packed, the boat on which it was shipped, and the time of the year shipment was made. The tabulations made reveal the following main facts: The decay in grapefruit ranges from practically nil with some growers up to 15 per cent in shipments from other plantations. Oranges show considerable decay, regardless of where they are grown; seldom less than 5 per cent, usually 10 to 15 per cent, and frequently 25 to 50 per cent. The decay of pineapples ranges from nil to 10 per cent. The fruit from several plantations shows no decay; from a great many others the decay is less than 5 per cent. Occasionally, however, the figures are as high as 20 or 30 per cent. This great variation in decay of fruit from the different plantations has made it impossible to determine the influence of handling in the packing house. Moreover, it is not safe to draw conclusions from the results of one boat over another. It is true that personal observations greatly aid in making the figures much clearer, and for this reason an effort is being made to keep personally in touch with all phases of the problem. The information at hand now, although not complete, has already been of great help to individual growers.

While the decay of grapefruit and pineapples is relatively not large, the actual loss caused by it is considerable. The loss due to decay of fruit, excluding the oranges, is more than \$100,000 annually. The loss from decay in oranges can not be calculated from the data at hand. Approximately, three-fourths of the oranges shipped from Porto Rico are the so-called wild fruit. No data have been collected on these, but the loss on them is always very great. For this reason \$100,000 will perhaps be a low estimate for oranges.

The loss of the fruit itself and the very high repacking charges are small matters compared with the actual loss in money due to all of the fruits selling at a lower price on account of the decay. That loss can not even be estimated, but all those who handle Porto Rico fruit state that fruit rot is the greatest factor in the selling problem.

The problem of how to eliminate or lessen the decay in fruit must be attacked in the field, in the packing house, and at the different stages of shipping and storing. The shipping problem was the first attacked in this investigation, and it resolved itself into two factors—the effect of ventilation and the effect of temperature.

TEMPERATURE READINGS.

Weekly temperature readings were taken on the wharves in San Juan of the air and of the packed fruit awaiting shipment. Table 8 is a representative sample of these readings. The observations show that the air temperature of the wharves is very close to the average maximum temperature of the air in San Juan; also, that the temperature in the center of a packed box of fruit is several degrees lower than that of the air, even after the fruit has been on the wharf one or two days.

TABLE 8.—*Temperature on the wharf in San Juan in 1919.*

Month.	Air on wharf.	Air in center of packed box.	Month.	Air on wharf.	Air in center of packed box.
	° F.	° F.		° F.	° F.
September.....	85	82	December.....	81	77
October.....	88	83	January.....	80	76
November.....	80	75			

The officers of some of the fruit-carrying steamers were induced to fill in specially prepared blanks three times a day during each voyage. These blanks recorded the barometer readings, and the temperature of the air and water, as well as of the holds in which the fruit was stowed. The record also included the amount and kind of ventilation provided for the fruit, the cargo other than fruit carried in each hold, and the state of the weather throughout the voyage.

A summary of all the reports received shows the following facts, which are of special importance for the purposes of this investigation. The temperature of the air during the first two days out from San Juan ranges roughly from 82° to 75° F., according to the time of the year and the time of the day. On the third day out it is seldom much below 70°, except in the coldest months. During the rest of the voyage, 1½ to 3 days, the air temperature is governed by the time of the year.

During the first three days out from San Juan the temperature of the water shows so little difference from that of the air that it can exert no perceptible difference on the temperature of the holds below the water line. During this time the temperature of the holds may be kept nearly the same as the temperature of the air with natural ventilation, provided the weather is calm enough to allow for ventilation. The ships on which the records were kept were not fitted with artificial ventilation. The term "hold," as used here, means any free space in the hold.

The assumption that certain cargoes, such as sugar, develop more heat than certain other cargoes was not verified by the data collected.

Self-registering hygro-thermographs were kindly furnished by the Bureau of Plant Industry, United States Department of Agriculture, but it was not possible to make use of them on the ships; neither was it possible to study the effect on the fruit of the gases evolved in the holds. These problems are now under investigation.

INFLUENCE OF TEMPERATURE ON PACKED FRUIT.

Through the cooperation of an ice company, 24 boxes of grapefruit and oranges were placed in a room having a constant temperature of from 54° to 56° F. A small percentage of the fruit developed decay, and the experiment was discontinued. Facilities were next provided by a brewing company in a room having a temperature of about 40° F. For nearly two months self-registering hydro-thermographs were kept in this room showing a temperature of 35° to 40° F., and a relative humidity of 90, ranging from 85° to saturation. One or two dozen boxes of fruit were placed in the room from time to time and left there for from 1 to 8 weeks. As a result not a single fruit decayed that was not physically injured.

Among the many notes obtained the following are of especial importance: The time in which the center of a packed box of fruit cools down depends upon the closeness of the pack. Grapefruit cools more quickly than oranges, and unwrapped fruit cools more quickly than wrapped fruit. The same rule applies for heating up after the fruit has been cooled. Where the air temperature was 80° , a packed box of fruit showed an increase of 5° or 8° in temperature within the first hour after it was removed from the cool room. The temperature was taken in the center of the box. After the first hour the rise in temperature was more gradual. When the fruit was removed from the cool room the condensation was always very great. The tissue wraps became entirely soaked within a few hours, causing a mussy condition in the pack. Fruit which was kept in the cool room for 2 to 6 weeks and then removed to air temperature did not decay any sooner than fruit that was recently picked, provided the wet wraps were removed. Fruit which was physically injured—that is, having the peel bruised or scratched—did not break down in the cool room during a stay of 2 months; however, it did break down rapidly after it was removed into the air temperature. Perfectly sound fruit, when packed with fruit that had started to decay, did not become contaminated while in the cool room; that is, such fruit, when unpacked and dried, kept as well as fruit recently picked. Fruit in the first stage of decay, showing symptoms of stem-end rot, did not break down to the stage of leaking even when it was placed in the cool room for 6 or 8 weeks. The fruit which was kept in the cool room from 4 to 6 weeks or more showed more or less so-called scald spots.

These spots appear as brown, sunken areas in the peels. They do not impair the quality of the fruit but greatly reduce the selling value. The scald spots did not develop, however, on fruit which was kept in the cool room for one week only. In studying this problem it was found that wrapped fruit developed scald spot as well as fruit without wraps. Fruit that was purposely bruised and immediately coated with paraffin also developed brown spots. The spots developed only where the peel had been injured. Any bruise or spot turned brown; anthracnose spots especially were greatly aggravated. During the first two days the fruit was out of the cool room the spots were inconspicuous, but they showed up fully the third day, and more so the fourth and fifth days.

INFLUENCE OF PARAFFIN AND SHELLAC ON PACKED FRUIT.

The investigation of the influence of paraffin and shellac on packed fruit was suggested by F. S. Earle, of the Insular Experiment Station at Rio Piedras. Several lots of fruit were treated in the following manner:

The stem with the adhering calyx was pulled out, the stem cavity was sealed up with shellac in alcohol, and the entire fruit was then rubbed over with paraffin. No conclusive results were obtained with grapefruit, because the boxes that were under observation in Porto Rico did not show a perceptible amount of decay; the reports on the lots sent to New York were very much mixed. The results with oranges were conclusively negative, that is to say, the treatment did not prevent stem-end rot. For instance, one lot that was treated and kept for 10 days showed a decay of 8 to 16 per cent due to stem-end rot. Only one fruit showed blue mold out of 10 boxes. The check lot ran slightly below in stem-end rot, but several fruits showed blue mold. Blue mold, however, was not very troublesome at any time during the year.

The paraffin showed interesting possibilities as a protection against contamination and shriveling. Whether paraffin may be substituted for tissue wraps is a matter well worth considering. The tissue wraps are unquestionably of some value as a protection against the spread of blue mold, but they afford very little protection against contamination from a leaky fruit infected with stem-end rot. These points were brought out very clearly in inoculation tests. Sound grapefruit wrapped with a small piece of decayed fruit and laid on the stem end did not readily become infected; rather, the piece of decayed fruit seemed to dry up. A decaying whole fruit when packed always had the expected effect. Its juice leaked onto the adjoining fruit and soon contaminated half a box, although the fruit was wrapped in the usual manner. A piece of decayed fruit placed in a box of oranges usually produced contamination.

ORGANIZATION WORK AMONG THE FRUIT GROWERS.

Since the establishment of the office in San Juan, an effort has been made to organize the fruit growers, among other things, to carry out all investigations on a cooperative basis; to enable each one to derive immediate benefit from the solution of any problem; and to stimulate an interest in, and adoption of, progressive methods that have stood practical test. This effort has finally been crowned with success. As a result of several meetings held during the year, a Fruit Growers' Executive Committee has been appointed, representing the entire fruit interest of the island.

AGRICULTURAL EXTENSION NOTES.

The San Juan office prepares timely information on agriculture and issues it in mimeographed form. Each month an issue containing probably 1,000 words is sent out, 500 copies being in the English language and 12,000 in Spanish. In addition to miscellaneous matter, 24 important subjects were treated during the year. These publications are known as the "Agricultural Extension Notes," and can be had free of charge upon application.

MISCELLANEOUS WORK AT THE SAN JUAN OFFICE.

In addition to the work outlined above, the office keeps in touch with the special teachers of agriculture in the department of education as well as the Agricultural League. The constant effort is to collect reliable data on yields and cost of production of all crops in all localities. This information is of the utmost importance, but, unfortunately, it is very hard to get. The effort made so far has resulted in very little tangible evidence, but it has helped to open the way for future work.

REPORT OF THE AGRICULTURAL TECHNOLOGIST.

By W. A. MACE.

Investigational work was continued at the station with rice, cowpeas, soy beans, and the mung bean. Some experiments were begun with cotton. Plantings of cowpeas and soy beans were absolute failures this year. It was impossible to get a stand with these crops, owing to the extensive drought which prevailed throughout the spring. Several plantings were made, but each time the results were exceedingly poor.

The station distributed elephant or Napier grass (*Pennisetum purpureum*) as in other years, and reports from all parts of the

island show that plantings of this grass are giving encouraging results. Requests for cuttings and cultural directions continue to be numerous. During the past spring the station distributed about 500 pounds of seed of the mung bean to the farmers of the island. Distribution was made through the Agricultural League, agricultural teachers, and municipal officials to the small farmers and planters of such food crops as rice, beans, corn, and the like. The station has listed, from all parts of the island, the names of over 1,000 farmers who received the seed of the mung bean. It is early yet to expect reports on this seed, but it is hoped that the bean will do well because it is a much surer crop than any of the commoner varieties of beans.

Owing to lack of water for irrigation, nursery planting of rices received from the Office of Cereal Investigations, United States Department of Agriculture, was made in August of last year instead of in the early spring. The greater number of these rices suffered much from lack of water to mature the crop. The dry season set in early this year, coming on just about the time that the panicles were emerging in the rices. It was impossible therefore to mature the crop. This year the planting of the nursery to these rices was made early in the spring. A poor stand was obtained on account of the very dry season.

The samples of native rices which were collected last year were grown this year at the station. Data regarding them are interesting and valuable. When the 145 samples were classified it was found that they contained only 17 varieties of rice. In some of these varieties various strains were found. A few of them promise to be very prolific producers. It is probable that after selections are made for a few generations a very valuable strain can be obtained for planting on the hillsides throughout the island. Quite a number of samples when grown and classified were found to be wild rices. Of these there were four or five types. These, together with several other varieties found in the collection, are interesting only inasmuch as they furnish data or a reason for studying the plant. It is likely that they will be discarded. Further plantings have been made of the most promising varieties for continuing investigations.

The cooperative plantings made with the planters on the island during the past season were not very encouraging. It was impossible to keep the land submerged in these plantings, and the data desired concerning them could not be obtained. Some of the plantings gave fair yields, however, considering the adverse conditions under which they were grown. Two plantings were made in late summer with the idea of growing rice on land that is to be used for spring planting of cane. These gave fairly good results.

Some work has been carried on with small planters to help them in improving the rice industry on the island. This work consisted principally in introducing certain varieties of rice that are known to be superior to the native rice. This work is being continued and its results so far are exceedingly good.

During the year the station planted a number of grasses that were furnished by the Office of Forage-Crop Investigations, United States Department of Agriculture. Among these were Guatemala grass (*Tripsacum laxum*), Kikuyu grass (*Pennisetum longistylum*), the Merker grass (*P. merkeri*), and Cayenne grass (*Echinochloa polystachya*). All of these started out well, but none seems to do as well as the Napier grass. The Kikuyu grass was lost in cultivation. Some canes of the Cayenne grass grew to a length of about 13 feet and then succumbed to the dry weather. The Merker grass did well. It resembles Napier grass very much. Its canes are finer, however, and it does not produce as great a quantity of fodder as Napier grass. The Guatemala grass grew well through the dry season. It is a very slow grower, but it kept a beautiful green color throughout the extensive drought of last spring and summer.



